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SECTORAL TECHNOLOGY STRATEGY SERIES

No 2

The Canadian Automotive-Parts Sector

SECTORAL TECHNOLOGY STRATEGY SERIES

NO. 2 THE CANADIAN AUTOMOTIVE-PARTS SECTOR

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Highlights

- During the 1980s, the competitive balance among the world's automakers shifted dramatically in favour of the Japanese and away from the U.S. Big Three (General Motors, Ford, and Chrysler). Because the Canadian auto-parts sector is so closely linked to the fortunes of the U.S. Big Three, it is in an extremely vulnerable position.

- In addition to the increasing Japanese share of global vehicle and parts markets, suppliers must contend with slowing market growth and increasing overcapacity in auto-vehicle and auto-parts manufacturing. The inevitable worldwide shakeout in the automobile industry resulting from these trends could strike the North American and European car manufacturers and parts suppliers hard, unless they can close the competitive gap with the Japanese.

- The impact of the Japanese invasion on parts suppliers in North America has been dramatic. North American parts suppliers are not getting enough new business from the Japanese to compensate for losses from the Big Three, because many Japanese suppliers are following their clients, the Japanese automakers, and opening North American factories. Transplant assemblers source only about 12 per cent of their components from independent, domestic parts suppliers, whereas North American nameplates source up to 45 per cent. Exports to Japan are also very low, which is not surprising because entering a Japanese assembler's "family" requires extensive engineering capability, and Canada has little to offer in this area.

- Developing countries, such as Mexico, Brazil, and Taiwan, with lower labour costs, are a growing source of competition.

- As a result of the remarkable success of the Japanese, the automotive industry worldwide is undergoing a radical restructuring, and a new model is emerging for the industry — a model very close to that developed by the Japanese.

- The basic features of this model, sometimes called the "post-Japanese model," are:

  1. Tier structure among suppliers
  This model calls for an assembler to tier all its suppliers. Only Tier 1 firms supply components to the assembler directly, and they supply complete assemblies rather than merely subassemblies or parts. In turn, the Tier 1 supplier ensures the Tier 2 and Tier 3 suppliers meet their subcontracted duties.

  2. Fewer auto-parts suppliers
  Almost all automakers in Europe and North America have been reducing the number of their suppliers for several years. From several thousand key suppliers they are cutting back to several hundred (typical of Japanese assemblers).

  3. More capable suppliers
  The trend to assign suppliers greater R&D responsibilities favours the emergence of larger suppliers with comprehensive R&D capabilities.

4. Larger suppliers
Accompanying the move to fewer suppliers is the emergence of larger suppliers that can take advantage of economies of scale in automotive-parts production and generate the revenues needed for increased R&D.

- At present, R&D plays a minor role in the operations of North American parts suppliers. Although there are exceptions, the typical North American practice is that parts suppliers do not conduct R&D or design the parts they produce. R&D plays an even smaller role in the Canadian auto-parts sector than it does in the U.S. sector. Although Canada accounts for an increasing share of North American vehicle and parts production, R&D expenditures as a percentage of sales by the automotive sector in this country remain low compared with those of the United States and other auto-producing countries.

- The technology strategy of the Canadian auto-parts sector can be summed up as adopt and adapt. In this strategy, automotive firms import state-of-the-art machinery and then capitalize on lower Canadian labour costs. The business strategy underpinning this approach is differentiation by low manufacturing costs.

- Canadian parts suppliers can employ several strategies to ensure their viability and growth in the new competitive environment:

  1. Adopt a tier structure
  Until now, a buoyant world market has made it possible for North American and European assemblers to pay lip service to the post-Japanese model, while implementing few fundamental changes. However, if their market share continues to erode, North American assemblers will be *forced* to look to parts suppliers for technology. Thus, Canadian parts suppliers that pursue an innovation strategy now for Tier 1 status will most likely gain in the longer run.

  Companies that adopt this strategy will have "total systems integration capability"; that is, they will have the capability to understand (and, if possible, further develop) the complex parts and subassemblies that go into the efficient manufacture of the modern automobile. The Tier 1 companies, in turn, will have to manage their own suppliers to ensure their performance. Parts firms that do not offer engineered assemblies will be Tier 2 and Tier 3 candidates. However, even firms wanting to reach Tier 2 or Tier 3 will require greater technological sophistication than most now possess. Firms at all levels must build relationships in their "family" and must develop core corporate capabilities.

  2. Increase R&D investment
  To remain competitive in the auto-parts sector, R&D investment relative to sales (typically 1-5 per cent for major North American suppliers) may not be as important as the absolute value or scale of the R&D investment. Larger companies investing 5 per cent of sales in R&D have an obvious advantage over smaller companies.

  3. Make acquisitions and alliances
  In both Europe and North America, auto-parts companies now realize that they must be large enough to sustain the investments needed to compete on a global scale. Suppliers can grow rapidly through acquisitions or alliances with other companies.

4. Improve management techniques

A comparative study found that although the United States and Europe spent considerably more on automotive R&D than Japan (1984 figures), this had little bearing on their competitiveness. The reason seems to be that the Japanese model, which incorporates R&D at all stages of production (dynamic system of R&D), gives a far greater return on R&D investment. It means that technical expertise and know-how are embedded in the whole company, from top management to workers on the shop floor.

5. Enhance technology strategy

To survive in the new, restructured automotive sector, Canadian auto-parts firms have several options for business and technology strategies. The major decision will be at what level in the tier structure the company wants to compete and whether it has, or will be able to generate, the necessary resources.

- Interviews conducted on behalf of the Science Council with executives in some of Canada's leading auto-parts firms identified two priority areas in which they felt governments should take action — Revenue Canada should interpret R&D more flexibly and financing for R&D should be more readily available.

- A concerted effort should be made by interest groups, including auto-parts firms, auto assemblers, governments, research organizations, and trade associations to develop an action plan that would specify technology goals, memorandums of understanding between all the players, and reasonable accountability levels.

Background to the Sectoral Technology Strategy Series

In the emerging "new" economy of the 1990s, successful high-value businesses in advanced nations are being driven by innovation, propelled by spending on new products and processes. Their business strategies centre increasingly on specialized knowledge and skill in finding the right "fit" between their unique blend of core technologies and particular markets.

Where does Canada stand in this rapidly evolving new environment of changing linkages and relationships? The poor innovative capacity of Canadian industry has long been a concern of the Science Council of Canada, going back to its 1971 report *Innovation in a Cold Climate*. The Council re-emphasized this concern in 1988. It focused its attention on the potential for action at a sectoral level in its statement *A Sectoral Approach to Innovation*. It argued:

> There is growing recognition by industry and government in Canada of the key role played by technology and R&D in domestic and international competition. The Science Council considers that it is primarily the responsibility of industries to raise the degree of domestic technological sophistication and the level of R&D. Nevertheless, governments can help business to sustain long-term competitiveness both by building partnerships with individual firms and by generating consensus on the formulation of innovation strategies for the various industrial sectors. The intent is not for government to tell business what to do, but to facilitate business cooperation in a process of self-help. The process of building consensus on a strategy for a particular sector will involve close and on-going consultation with industries about the current role of technology and R&D in the sector, the opportunities foreseen, and the nature of the sources, stimuli, and forms of technological innovation. Obviously, to be successful, separate innovation strategies will be needed for each sector. The Science Council hopes that the process of building consensus will generate commitment and collective will concerning priorities, areas for cooperation, and agenda for action.

This statement proved to be an important step in the path that subsequently led the Council to undertake a major Sectoral Technology Strategy project.

In 1989, Industry, Science and Technology Canada, at a time of heightened concern for the state of Canadian competitiveness and serious questioning about the low level of Canada's gross expenditures on research and development as measured against other advanced countries, agreed to provide the main funding for this project. It also stipulated the selection of sectors on which it would like the project to focus.

Each report in this Sectoral Technology Strategy Series draws in part upon analyses commissioned by the Science Council of Canada from contractors, designed to reveal the key dynamics driving technological innovation in the sector and influencing company technology strategies. Each report has also benefited considerably from the comments and advice submitted by the many external reviewers from business, universities, and government, who are recognized in the Acknowledgements.

Commentary on the Sectoral Technology Strategy Series and R&D Targets

The Sectoral Technology Strategy Series has analysed 15 Canadian sectors. On the basis of this experience, the Science Council of Canada makes the following points with regard to Canadian R&D performance and the issue of setting sectoral R&D targets.

- Canadian firms, when grouped by sectors, generally perform much less R&D than their trade competitors. Using the indicator of R&D as a percentage of sales, Canadian firms undertake R&D at a rate about one-third to one-half the rate of their leading international sectoral competitors. The notable exception among those sectors analysed in telecommunications.

- In some product lines or specific technologies certain absolute threshold levels of R&D and capital investment must be reached if the effort is to be considered to have a chance of making a commercial payback. High thresholds are apparent in some parts of sectors such as telecommunications (central office switches), automotive parts ("Tier 1" supplier status), oil and gas (reformulated gasoline standards by refineries), and electronics (integrated circuit foundry). Such absolute thresholds cannot be clearly expressed as a percentage of sales.

- The reasons for the lower level of R&D spending by firms in most of the 15 Canadian sectors are: choice of business and technology strategy (which, in part, leave Canadian companies as essentially non-participants in many higher value-adding segments); the relatively small size of Canadian firms; the high absolute thresholds of R&D expenditure required to be a meaningful player, especially for innovative technology strategies; and the degree of foreign ownership of Canadian firms (especially important in the case of the automotive vehicles and parts sectors).

- The lack of R&D relative to other countries affects Canadian competitiveness, but it is only one of many factors, such as capital and labour costs, quality design, good marketing, and management, that interact to affect overall competitiveness. Nevertheless, the contribution of R&D, or more precisely, technology-based innovation, is becoming more pronounced throughout the global economy and Canada continues to fall behind. The low level of R&D is especially detrimental to the capacity of Canadian resource-based sectors to compete with higher-value, differentiated products, leaving them vulnerable to adverse shifts in costs beyond their control, such as a higher exchange rate.

- Major potential does exist for Canadian industry to make additional R&D investments. However, fulfilling this potential depends heavily on the vision and capability of management to make strategic use of technology, to speed the firms' innovation process, to work more closely with suppliers and "demanding customers" all the way to the end of the product chain, and to build core capabilities in incremental innovation and R&D. Canadian firms have not yet fully grasped the implications of the emerging new "lean enterprise" or "agile producer" strategy. To follow this new strategy involves seeking to offer maximum value to customers. It requires integrating the skills base of a knowledgeable workforce with flexible management structures that stimulate cooperative initiatives within and between firms to match customer needs.

- The dominant technology strategies being followed by Canadian firms in these sectors are of adopt and adapt. Innovation technology strategies are not very extensive (telecommunications is again an exception) and hardly any firms focus on breakthrough strategies to enhance competitiveness. Overall, these 15 sectors show little attempt at diversification out of existing product lines as opposed to making such products more efficiently.

- Governments can set sectoral R&D targets in the hope of stimulating enhanced industrial performance, shifts in business strategy, and greater commitment by the private sector to R&D. However, private sector R&D is only meaningfully undertaken in conjunction with a full complement of associated private and public sector actions ranging from improved design and production to finance and marketing. Doing more R&D will not be productive unless linked to a broader corporate technology strategy that is carefully designed to support the firm's business objectives. Otherwise, the corporation cannot, and will not, marshal the complementary investments required to reap the benefits of the R&D. It is the firm that must commit R&D resources.

- Setting sectoral R&D targets becomes more difficult as the boundaries between sectors are breaking down, through technological advances, regulatory change, and firm restructuring. Larger and more diversified firms that dominate modern industrial R&D perform R&D that might be allocated to any of several sectors. Examples include the textiles and materials R&D performed by large Japanese steel firms, the electronics R&D by automotive-vehicle firms, and the software R&D by telecommunications firms. Canadian governments have quite correctly encouraged higher levels of industrial R&D in Canada. In view of the rapid pace of scientific advances and technological change, plus the role of system interdependencies and synergies between technologies, setting R&D targets does not appear to be a task warranting the intensive effort, cooperation, and, ultimately, commitment that would be required by federal and provincial governments and private sector organizations.

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No. 14 The Canadian Electronics Sector
No. 15 The Canadian Computer Software and Services Sector

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Introduction

The Canadian automotive-parts industry is struggling in one of the world's most competitive sectors. The stakes are high: any firm not keeping up will go out of business. But the opportunities are also substantial: the chance to upgrade technologically, including doing R&D, in a way firms have never had before in this sector. Can the Canadian industry survive and prosper during this upheaval?

The main objectives of this report are to indicate the technology strategies of leading Canadian auto-parts firms and how the sector performs in R&D compared with our main trade competitors. The report also outlines major reasons for any differences in performance and how these affect our competitiveness.

Overview of the International Automotive Sector

The Changing Competitive Balance

During the 1980s, the competitive balance among the world's automakers shifted dramatically in favour of the Japanese. Although the U.S. Big Three (General Motors, Ford, and Chrysler) achieved record profits, their market share declined steadily, even in their traditional North American stronghold. Sales of Big Three passenger vehicles in North America declined from 82 per cent of the market in 1978 to 64 per cent in 1988, while sales of imports increased from 18 to 29 per cent. Overseas companies that manufacture vehicles in North America — the "transplants" — accounted for 0.2 per cent of the North American market in 1978, but nearly 7 per cent in 1988.[1] By 1990, Detroit's Big Three were facing major losses: for example, in 1990, General Motors had a $2 billion loss, Ford had a $519 million loss, and Chrysler suffered similar losses.

According to industry analysts, the reason for the relatively poor showing of U.S. and European auto manufacturers is that they remain behind the Japanese in productivity, costs, quality, and (perhaps most surprisingly) technology.[2] Moreover, by most accounts, the performance gap between the North American and Japanese manufacturers widened during the 1980s. Organizational considerations such as product development cycles, product life cycles, and flexible manufacturing favour the Japanese. Also in their favour at present are financial considerations such as health-care costs, pension costs, and the cost of capital.

Perhaps the most important factor behind Japan's success is the way the Japanese automotive industry is organized and managed. For parts supply, the industry is vertically integrated. Assemblers and parts suppliers cooperate at all stages of the design and development of vehicles and parts. In contrast, North American parts companies still largely bid to manufacture parts that are designed and developed in the research departments of the vehicle assemblers.[3]

In addition to the trend of increased Japanese share of the international vehicle market, U.S. and European manufacturers must contend with slowing market growth and increasing overcapacity in vehicle and parts manufacturing. Because of these trends, there will be a shakeout in the automobile industry that could strike the North American and European car manufacturers hard, unless they close the competitive gap with the Japanese.

The Canadian auto-parts sector, bound by the Auto Pact to the fortunes of the U.S. Big Three, has also felt the pinch. It, too, faces major restructuring imperatives. But in the past few years the Canadian auto-parts sector has had a limited rate of return with which to finance necessary investments and, more important, it lacks the necessary technological expertise to make optimum use of investments in a new growth strategy. If Canadian auto-parts firms are to stay in business in a time of industry upheaval, they must upgrade their operations. Such upgrading will not be just technological; it will require rethinking their organizational structure and marketing strategies — an upgrading of total corporate capability.

Implications of Japan's Success for the Automotive-Parts Sector

The impact of the Japanese invasion on parts suppliers in North America has been dramatic, but even greater changes are in store for these companies. North American parts suppliers are not receiving enough new business from the Japanese to compensate for their losses from the Big Three, because many Japanese parts suppliers are following their clients, the Japanese automakers, and opening North American factories.

These Japanese suppliers share organizational skills and technological competence honed by their intense domestic competition. Thus, although Japanese automakers in the United States bought about U.S.$6 billion worth of U.S.-made parts in 1989, double the 1988 level, most were purchased from the 300 Japanese-owned or joint-venture plants in North America. Exports from North American-owned plants to Japan are low, as are their sales to Japanese transplants. The growing number of Japanese vehicles on North American roads thus represents a net loss of business for indigenous North American parts producers.[4]

Some of the difficulties North American parts suppliers have in selling to Japanese automakers result from the difference between the organizational structures of the North American and Japanese vehicle industries. Japanese assemblers work with their own "family" of parts manufacturers, and they often maintain substantial equity in their parts makers. The close working relationship between auto company and parts producers results in a high degree of de facto vertical integration. In contrast, the North American sector evolved through a competitive rather than a cooperative process. Independent parts producers have always bid for contracts.

Because assemblers and parts manufacturers in Japan work together from the inception of a vehicle, foreign companies have had great difficulty gaining access to business in Japan. Typically, purchasing decisions of transplant assemblers are made in Japan because vehicles are still designed there. It is only in the last two years that many Japanese auto companies have established positions within their purchasing groups to deal with foreign suppliers. This has created somewhat better access to the Japanese market. However, according to the Japanese transplant firms, North American parts companies lack the technological expertise to join the vertically integrated Japanese structure; in particular, North American parts firms are generally excluded from engineering projects. As a result, their sales prospects — exporting parts to Japan and supplying North American transplants — are limited.

Until now, the European auto sector has been able to protect itself from Japanese competition through local content. The Japanese strategy in Europe, therefore, is somewhat different from that in North America. Instead of setting up independent operations in Europe, the Japanese parts manufacturers favour acquisitions and joint ventures. Japanese assembly plants in Europe must achieve 70 to 80 per cent local content immediately for their automobiles to qualify as European-made and therefore free to enter the European Economic Community without restrictions.

However, the European auto sector is likely to be just as vulnerable as its North American counterpart to the Japanese challenge. Because Europe has more independent manufacturers of auto parts than does North America, there are many more acquisition opportunities. One leading example is the acquisition of IMI Radiators, Europe's largest radiator manufacturer, by Nippondenso.

In both North America and Europe, the implications of the Japanese invasion are essentially the same. Only the best parts firms will compete in the global marketplace for automotive products. They will absorb the technological, managerial, and manufacturing implications of the new techniques — sometimes referred to as the "lean production model." These firms will grow and prosper. Some of the better firms may also be bought out, particularly by Japanese firms that are looking for a base for local production. Those companies that are not the best will be forced out of the automotive business.

Restructuring of the International Automotive-Parts Sector

As a result of the remarkable success of the Japanese, the automotive industry worldwide is undergoing profound technological and economic changes. To remain competitive, assemblers and parts suppliers in North America and Europe are adopting some of Japan's strategies, which will transform not only the way assemblers and parts suppliers do business, but also their relationship with each other.

By the early 1980s automakers in North America and Europe began to re-evaluate their operations and identify which of the key Japanese procedures they could adapt for their own use. Compared with the leading Japanese players, their industries seemed top-heavy with administrative and engineering staff. Moreover, the traditional procedure of having suppliers work to drawings, and generally contribute little to the design of the vehicle, was wasting substantial engineering resources and, in some cases, duplicating them. This had led to high allocated overhead costs, which increased the price of each new car — a serious competitive disadvantage. Assemblers and suppliers had also become complacent about delivery, quality control, and each other's welfare; their relationship was largely adversarial.

In contrast with North American and European practice, the relationship between assemblers and suppliers in Japan was cooperative. Japan's vehicle manufacturers kept their operations lean and efficient, in part by out-sourcing almost all non-drivetrain-related components, and by devolving component design, development, and testing to Tier 1 suppliers who delivered complete assemblies or systems to the assemblers. Assemblers and suppliers were often linked by equity exchange, dealt in very long-term contracts, practised continual improvement, shared product development, and applied themselves to a new method of manufacturing. This method emphasized delivery performance. The Tier 1 suppliers, in turn, sourced assembly parts from Tier 2 and Tier 3 suppliers — the latter mainly production-line operations.

There is one other major benefit to this "family" system of Japanese vertical integration: cooperation extends to purchases of the final product. This is a very important point. Workers and managers of the parts suppliers know they are linked to a particular assembler by the extended tier family. The assembler will buy their parts. In turn, they will buy the assembler's vehicles.

This structure creates a mutually exclusive market. Even if tariffs are very low — as the Japanese government claims — foreign cars do not sell well in Japan. Too many people know where their interests lie, as a result of the integrated system of tiering (and, indeed, the interlocked system of companies that make up a so-called "keiretsu" group).

Questions have arisen, however, about the extent to which the structure of the Japanese automotive sector can realistically be replicated in the North American environment.[5] In Japan, the cooperation between vehicle manufacturer and parts supplier is fostered by the fact that the auto industry operates as a very large vertically integrated system. Despite the ostensible independence of the parts suppliers, they are not really independent at all. The vehicle manufacturer's large equity holdings and its financial institutions ensure that the supplier has long-term viability and the capital for investments. Engineers are exchanged between parties to speed product development, and often the vehicle manufacturer provides key managers to the parts supplier.

During the 1980s General Motors, Ford, and Chrysler set out to emulate the Japanese companies by slashing engineering staff and rationalizing their supplier base. They assumed this would encourage the development of a select group of Tier 1 suppliers. These full-service suppliers, like their Japanese counterparts, would assume responsibility for design, development, and testing, as well as coordinate lower-tier suppliers.

This out-sourcing has been accompanied by longer-term contracts. But the atmosphere of trust necessary for parts manufacturers to make major commitments of resources to R&D has not yet developed. Despite longer contracts and increased design opportunities, suppliers still question the willingness of the Big Three to enter into long-term relationships. Researchers in the International Motor Vehicle Program (IMVP) of the Massachusetts Institute of Technology found that, on balance, suppliers felt if they wanted to incorporate new technology into their products and processes, or they encountered development or production problems, the Big Three would not be there when needed.

Today, there is general agreement that, even if the Japanese way is not fully transferable to the West (for cultural reasons), a new model is emerging for the North American and European industry — a model that is very close to that developed by the Japanese.

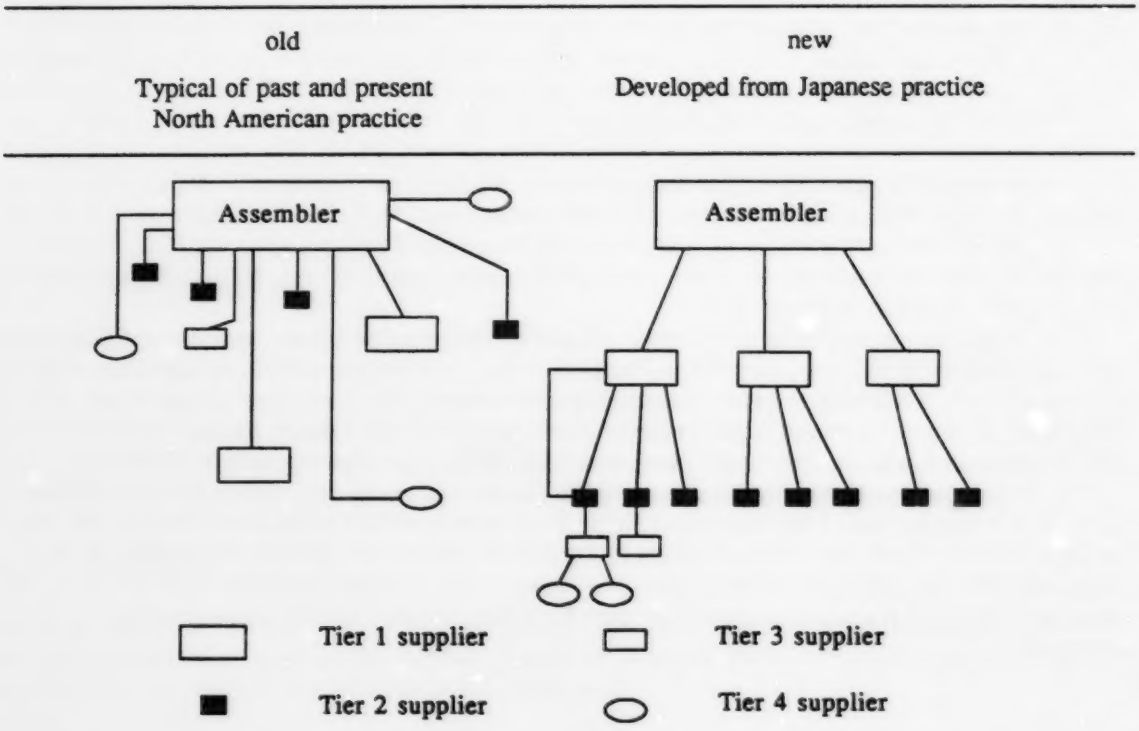
This new model, sometimes called the post-Japanese model, is designed for the emerging global industry. It adopts the lessons learned in the 1980s, yet takes advantage of the new opportunities offered to vehicle assemblers and parts suppliers in the 1990s.[6]

The post-Japanese model has gained widespread acceptance within the industry. The basic features of the model are (see Figure 1):

- a tier structure among suppliers;
- fewer auto-parts suppliers;
- more capable suppliers; and
- larger suppliers.

Figure 1. Illustration of vertical-integration models in automotive parts

The integration structure within the automotive sector is changing. This is the tiering phenomenon.



A Tier Structure Among Suppliers

The new model calls for an assembler to tier all its suppliers. Only Tier 1 level firms supply parts to the assembler directly, and they supply complete assemblies rather than just parts. In turn, the Tier 1 supplier ensures that the Tier 2 and Tier 3 suppliers meet their subcontracted duties. In general, the higher the tier, the higher the value added to the supplier's product, because the opportunity to do brain-work as opposed to brawn-work is greater in terms of R&D, management, and design. Because Tier 1 suppliers also have the R&D and design responsibility for the assembly, they must have or acquire new technological capabilities.

Tier 1 supplies assemblies or so-called "systems" to final assembler:
e.g., - complete seat assemblies,
- door assemblies,
- air conditioning systems, etc.

Tier 2 supplies subassemblies for an assembly or system:
e.g., - seat rails,
- fender outer skin,
- door outer skin,
- window winder mechanism, etc.

Tier 3 supplies parts for subassemblies:
e.g., - a single metal stamping,
- a moulded plastic part, etc.

Tier 4 supplies raw material for parts:
e.g., - steel sheet,
- plastic resin matrices,
- synthetic rubber compounds, etc.

This model implies only a few hundred direct suppliers to an assembler — Toyota, for instance, has 280. In contrast, each North American assembler currently has thousands.

The tier structure is attractive, and assemblers have voiced strong support for it. It can give assemblers competitive advantages in cost control and development flexibility, because parts suppliers can contribute expertise and innovation.

Despite its attractions, however, there are strong barriers in the North American and European auto industries to the new tiered approach. The lack of trust between assemblers and suppliers means that assemblers are reluctant to hand over design and sourcing to Tier 1 suppliers or pay suppliers for these extra services. The recent downturn in the North American auto industry has led to retrenchment among automakers who, in some cases, have even taken design and sourcing back in-house.

In her book on General Motors in the 1980s, *Rude Awakening*, auto analyst Maryann Keller writes that it was not until 1985 that Roger Smith, the chairman of GM at the time, changed his views on parts sourcing. Until then, GM had followed a policy of competitive bidding for obtaining parts. Only after 1985 did the power of the cooperative family model, or some variant of it, hit home. But it takes years to develop a new managerial structure for a huge industry such as manufacturing automobiles.

Fewer Automotive-Parts Suppliers

At present, there are about 5000 auto-parts suppliers in the United States and Canada; the Western European industry is even more fragmented, with an estimated 11 000 suppliers. Many of these suppliers sell directly to an assembler. In contrast, automotive assemblers in Japan have only 170 to 300 direct suppliers.

Almost all automakers in Europe and North America have been reducing the number of their suppliers for several years. This reduction is a response to several factors. Automakers have to reduce purchasing overhead costs. By cutting back to several hundred key suppliers, instead of purchasing from many thousands, internal staff can be reduced and better utilized. Also, closer cooperation between suppliers and assemblers will lead to faster product development and more efficient use of assets.

The Ford Motor Company may have taken the lead among the U.S. Big Three by establishing guidelines that will cut between 400 and 600 suppliers from its current 2100. Ford expects its suppliers to become full-service suppliers, collaborating with its designers and engineers early in product development and developing systems on their own. Because of Ford's global product development, the company will favour suppliers that have achieved world scale in their operations.

A good example of Ford's new approach to selecting suppliers is its relationship with Excel, a parts supplier that is now developing the complete door assembly for forthcoming models of the Ford Taurus/Mercury Sable line. Ford sets the envelope parameters, such as size of door opening and shape of exterior sheet metal, and Excel then provides the door, complete with window glass, opening mechanism, locks, handles, etc. Excel's new system integration capability was instrumental in the company's being awarded the contract. However, Ford first insisted that Excel acquire assets that increased its annual sales from approximately $250 million to $1.2 billion; Ford helped arrange financing for acquiring these assets.

Other auto assemblers are following Ford, and it is likely that the total number of direct or major suppliers in the United States and Canada will be reduced to fewer than 1000, and indirect suppliers to as few as 2000. In Europe, a reduction to about 1000 Tier 1 suppliers is also likely.

There is a sense of urgency among suppliers because the restructuring of the parts industry will be virtually complete by 1995-97. Already, half of Ford's supply contracts run for five years. For the chosen companies, this is good news because they can plan their investments accordingly. Those firms left behind, however, are closed out of the business for five years instead of one.

More Capable Suppliers

Despite the reluctance of assemblers to give up control over any part of their operations, their executives avow that suppliers should, in the future, do more product development. This will favour the emergence of larger, more capable suppliers with comprehensive R&D capabilities.

One of the criteria General Motors uses to select suppliers is that they must spend on R&D an amount equal to one per cent of their sales. R&D capability of suppliers is also a selection criterion for both Ford and Chrysler, although they do not specify a particular R&D to sales ratio.

Larger Suppliers

Fewer suppliers generally means larger suppliers. Larger firms can take advantage of economies of scale in parts production, generate the revenues needed for increased R&D, and serve several customers. Survey evidence indicates this is now happening.

European and North American parts suppliers now identify growth as a major strategy and foresee acquisition and internal growth as equally important.[7]

The key issue, for all levels of tiering, is whether companies can change from the "old" system of simply processing to specifications to the "new" system of applying knowledge inherent in the company to respond to the needs of the assembler. This is known as the "Black Box" concept of development, in which the supplier provides an assembly, and the assembly may contain subassemblies or parts based on new technology that the supplier has developed itself.

Canada's Role in the International Automotive-Parts Sector

Canada's automotive industry has been dominated by U.S.-based firms since 1904, when the Ford Motor Company established a manufacturing branch in Windsor, Ontario. Their integration was tightened considerably by the Canada-United States Automotive Products Trade Agreement of 1965, commonly known as the Auto Pact.

The Auto Pact developed an integrated North American production-marketing system by abolishing tariffs on assembled vehicles and original equipment (OE) parts. Thus, access to the U.S. market was secured for Canadian vehicle assembly and parts plants.[8]

Mainly because of the Auto Pact, the Canadian share of North American vehicle production grew from 7.1 per cent (846 000 units) in 1965 to 14.6 per cent (1 977 000) in 1988. Some industry observers expect Canada's share to continue to grow, reaching between 18 and 20 per cent by the mid-1990s. Canada's share of North American parts production has also increased, from 9.8 per cent in 1982 to 13.1 per cent in 1986.[9]

Despite this increase, the growing sales in Canada and the United States of cars built overseas has depressed the growth of North American production as a whole since the late 1960s. If it were not for manufacturing facilities established by overseas-based automakers in North America (the transplants), North American-built vehicles could be losing market share even faster than they are.

There are four transplant facilities in Canada: Honda in Alliston, Ontario; Toyota in Cambridge, Ontario; General Motors-Suzuki (CAMI Automotive) in Ingersoll, Ontario; and Hyundai in Bromont, Quebec. The transplants represent investments of more than $1.6 billion, with production capacity of more than 430 000 units per year.

New investment in Canada has stemmed from both Asian-owned vehicle and parts transplant facilities and from North American plant modernizations. The number of foreign-owned (wholly owned by the Asian vehicle companies or independent) and joint-venture parts facilities has grown rapidly in recent years; total investments are in the hundreds of millions of dollars. In addition, General Motors, Ford, and Chrysler have made comparable investments in Canada, and General Motors alone is planning to spend up to $8 billion to upgrade its Oshawa complex over the next 10 years — if the investment can be justified by keeping the plant internationally competitive during the decade.

The increasing relative importance of Canadian production in the North American automotive sector is the result of several factors: competitive Canadian exchange rates (until recently), competitive wages, lower costs of benefits (in part from government health insurance), and a quality-conscious work force.

Some of Canada's competitive edge in attracting automotive production and investment, however, is threatened by the escalating Canadian dollar relative to its U.S. counterpart. Representatives of the parts industry point to a U.S.$0.80 exchange rate as critical for Canadian competitiveness.[10] In 1991, the Canadian dollar was trading above U.S.$0.86.

Overview of the Canadian Automotive-Parts Sector

The Canadian auto-parts sector, like the vehicle assembly industry, underwent major restructuring after the 1965 Auto Pact. Before 1965, the Canadian parts sector operated behind high tariff barriers and was becoming inefficient — so inefficient that the vehicle assemblers were increasingly opting to pay the tariffs and import parts from the United States.

The Auto Pact eliminated tariffs on OE parts and assembled vehicles. (Under the Canada-United States Free Trade Agreement, remaining tariffs on aftermarket parts will be removed by 1994.) The Auto Pact forced Canadian parts manufacturers to compete on equal terms with those in the United States, and some were forced out of business. However, the survivors had unimpeded access to the U.S. market.

One result of this restructuring under the Auto Pact was that control over the Canadian parts industry became centralized in the United States just as had occurred with vehicle assembly. Research, design and development activities, and key production decisions in Canadian branch plants of multinational parts firms were taken over by the parent firm. Plants were retooled to specialize in a limited range of products for the entire North American market. Essentially, the Canadian branch plants became solely production-line facilities.

Although control within multinationals became centralized in the United States, the Canadian presence in parts manufacturing began to grow again in the late 1970s. Canadian-owned companies, including Magna International, A.G. Simpson, and the Woodbridge Group, emerged as important and aggressive players on the North American scene. Almost 20 per cent of Canada's capacity to manufacture OE parts is now Canadian owned, compared with 4 per cent in 1970.

One of the reasons for the growth in Canadian auto-parts manufacturing was that the Canadian companies achieved a reputation for good-quality products. Indeed, Canadian firms have been awarded a disproportionately high number of awards for quality from the Big Three.

The rapid growth over the past 10 years has made Canadian automotive parts an important sector of the Canadian economy, accounting for about 5 per cent of the value of all manufacturing output. In 1987, the value of Canadian output of parts was $13.3 billion, accounting for about 30 per cent of the total output of parts and vehicles (approximately $41 billion). About 45 per cent of Canadian parts are produced by the vehicle assemblers themselves; the remaining 55 per cent are produced by independent firms. These firms manufacture parts as their main business or as a component of their business.

Despite its rapid growth, the Canadian auto-parts sector has a lower proportion of the North American auto-parts market than the Canadian vehicle-assembly sector has of its market. Whereas Canadian auto-parts production now amounts to about 13 per cent of total North American auto parts, Canadian vehicle assembly produces about 14.6 per cent of total North American output.

Productivity appears to be lower among Canadian auto-parts suppliers than their foreign counterparts — value added is C$38.28 per person-hour in Canada but C$50.83 in the United States.[11] This difference reflects, in part, the more labour-intensive work of the Canadian sector. Lower productivity may be why the Canadian auto-parts sector has not done relatively as well as the Canadian vehicle-assembly sector.

There is evidence that Canadian parts plants are smaller than those in the United States. In 1986, 560 manufacturing plants in Canada listed their primary activity as making automotive parts.[12] An additional 1500 establishments also made some auto parts, but these parts represented less than 50 per cent of their total output. Total employment in auto parts was about 85 200 people.

The sector is characterized by companies that employ, on average, fewer than 200 employees. Companies in the engine and engine-parts subsector are among the largest (average 320 employees); they also rank first in the value of total output and in productivity (output per employee) (Table 1). However, in 1986 there were only 50 companies in this subsector compared with, for example, 96 in the plastics subsector where the value of outputs and productivity is only half that of the engine and engine-parts subsector. In fact, most companies are in subsectors with much lower productivity and lower value added per employee than the engine and engine-parts subsector.

Table 1. Canadian automotive-parts sector (1986)

Subsector	No. of plants	No. of employees	Value of shipments ($ million)	Average employees/ plant	Average shipments/plant ($ million)	Average shipments/ employee ($)
Engines	50	15 988	3 430	320	68.60	214 402
Stamping	86	12 652	2 112	147	24.56	166 930
Brake-wheel	47	7 351	1 087	156	23.13	147 871
Other	190	23 361	3 430	123	18.05	146 826
Steering	35	5 378	720	154	20.57	133 879
Fabrics	20	6 628	877	331	43.85	132 317
Plastics	96	12 309	1 252	128	13.04	101 714
Wiring	28	5 120	398	183	14.21	77 734
Average				193	28.37	140 209
Total	552	88 787	13 306			

Source: Statistics Canada, *1986 Census of Manufacturers.*

Note: Tires are not included in the auto-parts sector for this report.

In the engine and engine-parts subsector, the average value of the output per plant was about $69 million, whereas for the wiring and plastics subsectors, the figure was closer to $13-14 million. The large number of small Canadian companies with low productivity ratios (that is, that are labour intensive) makes this sector especially vulnerable to competition from countries with cheaper labour than Canada.

Approximately 95 per cent of total output in the Canadian auto-parts sector is exported. Nevertheless, the sector has a trade deficit: in 1986, total exports were $12 billion, but imports totalled $19 billion.

The Canadian auto-parts sector also faces competition from, and investment by, overseas-based parts suppliers. Many of these have been highly successful, and they bring with them their managerial skills and organizational structures. About 20 Japanese and 40 European parts companies have manufacturing plants in Canada, through either wholly owned subsidiaries or joint ventures. These plants put Canadian parts suppliers under even greater competitive pressure. Some Japanese firms have set up facilities in Canada to be near transplant assemblers with whom they have close relationships in their own country. Other foreign firms have invested to gain access to North American assemblers or to allow North American assemblers access to world-class technologies.

Canadian companies have not been able to achieve reciprocal penetration of either transplant markets or offshore parts markets. At present independent domestic parts suppliers provide only about 12 per cent of all components used by transplant assemblers, whereas they provide up to 45 per cent of components used for North American nameplates. Exports to Japan are also very low. This is not surprising because Canada does not have the innovative engineering capability needed to enter a Japanese assembler's "family." Lastly, developing countries such as Mexico, Brazil, and Taiwan, with lower labour costs, are also a growing source of competition for parts produced by lower-tier suppliers.

The Role of Competition and Cost Pressures in the Sector

Both globally and in North America, the intense competition in the auto-parts sector is driving much of the industry's restructuring and its rapid technological change. Canadian parts suppliers have recently been under even more intense competitive pressures from the Japanese parts firms.

The profitability of the sector in both Canada and the United States does not appear to be very high. According to a recent major study by Booz Allen & Hamilton Inc. for the Auto Parts Manufacturers' Association of Canada, the profitability of Canadian auto-parts manufacturing was steady during the 1980s at approximately 7.5 per cent of total revenues annually.[13] However, profits dipped substantially in 1988 to 5.9 per cent. U.S. firms showed similar profit profiles. The dip is significant in light of the need for new investments.

This modest profit profile, moreover, has to be viewed in light of recent price trends in auto parts and in light of the competitive pressures on parts manufacturers during the 1980s. Booz Allen & Hamilton Inc. show price indices for auto parts in relation to both the Consumer Price Index (a reasonable index of general price inflation) and an index of new car prices.[14] The latter two indices increased by 20 per cent from 1982 to 1988, while auto-parts prices increased only 5 per cent — equivalent to a 15 per cent decline in real prices of auto parts.

Major assemblers have been quite explicit about their expectations of cost savings from suppliers.[15] At a meeting in the late 1980s with its suppliers, Chrysler Corporation even laid out its expectation of a 5 per cent annual decline in real prices from suppliers to maintain Chrysler's competitiveness. This earned the meeting the accolade of Chrysler's "Soup Kitchen."

It is possible for parts manufacturers to gain cost advantages through economies of scale. A British study of the European auto-parts sector shows that costs can be reduced by up to 6 per cent for rubber mouldings if production increases fourfold and by up to 7 per cent for interior mirrors if production increases tenfold.[16] Although the findings cannot be indiscriminately transferred to the Canadian sector, similar advantages could be gained by Canadian suppliers.

From the various cost studies in the auto-parts sector, it can be concluded that:

- Production costs are neither proportionate to scale nor linear. Economies of scale, together with the necessity of making periodic new investments, create "step" functions in which certain optimum levels of production become apparent, and parts manufacturers have to reach a certain threshold of output to achieve maximum gain.

- Cost savings from economies of scale are very significant because of the intense cost pressures in the sector.

- Parts manufacturers must know what their assemblers want. In some cases, economies cannot always be realized because of the assembler's design priorities and styling changes.

Flexible manufacturing systems (FMS), which are finding their way into the auto-parts sector, offer considerable potential for production economies; however, they require high capital investment and major organizational change. Volvo Components in Sweden, which has installed many FMS systems over the past five years, found that the investment cost of FMS can be very high (up to 20 per cent higher than the equivalent capacity of standard machine tooling) because only large throughput and utilization can justify the initial high capital costs.[17] However, the advantages of FMS include shorter lead times and superior machine utilization; 10 to 20 per cent savings in tool costs per unit output; and up to 50 per cent fewer machines and 50 per cent fewer workers for a given output.

This results in a cost reduction of up to 25 per cent per unit produced. Other advantages include better quality control and higher quality, reduced inspection costs, and improved working conditions.

Saving 5 per cent per unit cost from scale economies, or saving 25 per cent per unit cost from FMS, is vital for future productivity and growth in this sector. But to afford the investment costs associated with larger production runs or FMS, Canadian auto-parts companies will require high utilization rates (constant high output) to remain competitive. Because the total market (total car sales) is essentially a fixed number annually, it is inevitable that only larger companies will realize these economies.

R&D in the Canadian and North American Automotive-Parts Sector

Traditionally, R&D played a minor role in the operations of North American parts suppliers. Few North American suppliers conducted R&D or designed any parts they produced. Assemblers tended to conduct R&D and produce design specifications. These were given to parts suppliers who competed largely on price. Contracts for supplying a part were usually for one year. Thus, with no long-term guarantees for their products, there was little incentive for parts suppliers in North America to perform R&D.

However, this situation is changing. According to a survey carried out as part of MIT's IMVP program, about 70 per cent of suppliers now participate in the design of their products, and 57 per cent do most, or all, of the design. From 1983 to 1988, the length of the average supply contract given to survey participants increased from 1.3 years to 2.5 years.[18]

Table 2 details, for 1988, sales and R&D expenditures of publicly traded companies in North America, by R&D/sales ratio, which ranges from 0 to 5 per cent. In general, larger auto-parts firms conduct, relatively, more R&D than small firms. There are, however, exceptions. Gentex, a small company that has an innovative light-sensitive mirror design that may spread through the industry, had an R&D/sales ratio of 4.7 per cent, despite annual sales of only U.S.$14.7 million.

Although only one Canadian company, Magna International, appears on the list, it is not the only Canadian auto-parts company that conducts R&D. Private corporations in the Canadian sector have substantial R&D operations. Table 3 shows Canadian R&D in auto parts. The names of the firms have been withheld to maintain confidentiality.

A major problem in comparing the level of auto-parts R&D in Canada with that in the United States, Japan, and other countries is the variety of definitions of R&D. Public Canadian companies tend to use standardized definitions for accounting and reporting, but private companies may not necessarily use these. Compared with other countries, official Canadian definitions tend to be narrow and focus on the "R" end of the R&D spectrum, whereas other countries include more of the "D" end. A detailed case study of a private Canadian auto-parts company, conducted for the Science Council of Canada, indicated that the company's R&D investment could be between $4.4 million and $12 million, depending on the definitions used. DesRosiers Automotive, in an informal survey of R&D carried out by Canadian auto-parts companies, estimated that the level of Canadian R&D is higher than publicly available data suggest. However, because few auto-parts companies conduct R&D in Canada, the exact figure is not a major issue — it would not alter the overall picture.

R&D plays an even smaller role in the Canadian auto-parts sector than it does in the U.S. one. For technical and economic reasons, the sector as a whole performs much less R&D than its major competitors abroad. Most of Canada's trade in auto parts is with the United States, relative to which Canada has lower labour costs (until recently) and higher capital costs. Accordingly, Canadian industry has tended toward relatively labour-intensive, small-scale manufacturing — a segment of the auto-parts sector that is not generally R&D intensive. The relatively low business capital investment needed to

Table 2. R&D and sales of selected North American publicly held auto-parts manufacturers (1988)

Auto-related company	Net sales (U.S.$ million)	Net income (U.S.$ million)	R&D (U.S.$ million)	R&D/sales (%)	Sales/ employee (U.S.$ million)
United Technologies	18 517.9	659.1	932.4	5.0	99 132
Twin Disc Inc.	187.3	10.6	9.2	4.9	113 475
Donnelly Corp.	198.3	5.4	9.5	4.8	100 711
Gentex Corp.	14.7	0.7	0.7	4.7	57 342
PPG Industries Inc.	5 616.7	467.6	227.0	4.0	153 730
Trinova Corp.	1 781.3	87.8	71.1	4.0	76 613
Eaton Corp.	3 468.5	212.3	121.7	3.5	91 445
Allied Signal Inc.	11 909.0	463.0	415.0	3.5	108 659
Cummins Engine Inc.	3 310.1	(63.4)	95.7	2.9	126 824
Sun Electric Corp.	190.0	4.2	5.3	2.8	77 659
ITT Corp.	19 355.0	817.0	516.0	2.7	165 427
Carlisle Companies	567.4	17.4	14.0	2.5	131 279
Code Alarm	22.7	1.5	0.5	2.3	88 377
Spartan Manufacturers Inc.	33.5	2.3	0.7	2.0	194 686
Bandag Inc.	490.6	69.8	9.3	1.9	212 216
SPX Corp.	877.7	44.9	16.2	1.8	109 895
Parker Hannifin Corp.	2 520.2	124.5	46.0	1.8	75 320
Standard Products Co.	558.9	28.7	10.0	1.8	78 713
Gencorp Inc.	1 891.0	70.0	33.0	1.7	121 218
Danaher Corp.	715.7	44.0	12.0	1.7	108 438
Modine Manufacturing Co.	423.9	26.2	6.8	1.6	106 070
Federal Mogul Corp.	1 176.9	41.7	17.7	1.5	87 179
Champion Parts Inc.	129.5	1.6	1.8	1.4	49 420
Walbro Corp.	131.7	5.9	1.7	1.3	124 726
Dana Corp.	5190.2	162.2	57.0	1.1	131 398
Magna International Inc. (C$)*	1 923.7	33.6	19.3	1.0	109 923
Superior Industries International	200.2	13.1	2.0	1.0	99 379
Douglas & Lomason Co.	325.5	(4.0)	3.0	0.9	61 694
Excel Industries Inc.	259.9	7.0	2.2	0.8	103 972
Echlin Inc.	1 454.5	44.4	9.2	0.6	89 783
Defiance Inc.	64.0	2.6	0.3	0.4	86 311
Intermet Corp.	357.1	16.3	1.3	0.4	84 778
Simpson Industries Inc.	177.8	10.5	0.5	0.3	141 450
Collins Industries Inc.	120.1	(1.1)	0.2	0.1	117 133
Barnes Group Inc.	496.1	18.8	0.4	0.1	103 996
Federal Screw Works	73.1	3.5	0.0	0.0	136 979
Myers Industries Inc.	183.8	8.1	0.0	0.0	129 810
Voplex Corp.	75.1	2.3	0.0	0.0	71 127

Source: Maryann Keller, Furman-Selz Ltd.

Note: Some Canadian auto-parts firms are privately held (e.g., Woodbridge Foam) and cannot be included here because of confidential data. Woodbridge's total sales are estimated at approximately C$1.0-1.2 billion, and R&D expenditures are estimated at between C$4.4 and $12 million annually, depending upon the precise definition of R&D that is used.

* Canadian company

Table 3. Canadian automotive-parts R&D (1988)

Firm category	Origin	Total annual sales (U.S.$ million)	Annual auto R&D (U.S.$ million)	R&D/sales (%)
Annual sales				
$1 billion or more				
Alcan	Canada	8 600		1.1*
Magna	Canada	1 920	20	1.0
Woodbridge	Canada	1 000	5-10	1.0
Annual sales				
$100-900 million				
A	Canada	325	n.a.	
B	U.S.	253	>1.0	
C	U.S.	200	>1.0	
D	Canada	150	>1.0	
E	Canada	150	>1.2	0.6
Annual sales				
$50-100 million				
F	U.S.	100	1.00	1.0
G	Canada	50	0.25	0.5

Source: DesRosiers Automotive Research Inc., "Product Research and Development in the Canadian Automotive Parts Industry," contract report prepared for Science Council of Canada, 1989 (unpublished).

Note: Data from a 1989 survey. In 1986 Statistics Canada identified 425 auto-parts firms operating in Canada, of which 33 performed R&D. Of these, 12 had R&D programs of more than $1 million annually. Total parts R&D in 1986 was $52 million. R&D/sales ratio was 0.49%.

*Approximate

enter the sector, in the past, has resulted in many small firms that do not generate the sales to support even minimal practical R&D.

Another reason for the lower R&D of Canadian companies is their high degree of foreign ownership (80 per cent). A survey of the Canadian-based auto-parts firms, sponsored by the Science Council of Canada, found differences in the level of R&D performed in Canadian- and U.S.-owned companies.[19] Generally, Canadian-owned companies had higher R&D investments than foreign-owned companies. In the automotive sector as a whole, in 1986, Canadian-owned firms accounted for 17 per cent of parts shipments and 6 per cent of all automotive shipments, but they conducted 46 per cent of total automotive R&D in Canada.[20]

The focus of R&D by Canadian-owned manufacturers was also generally broader, encompassing company-initiated research as well as ongoing product and process development. In contrast, U.S.-owned branch plants perform little R&D, and most of that focuses on improving the product currently manufactured in Canada or on process-related concerns. For the most part, especially

product currently manufactured in Canada or on process-related concerns. For the most part, especially for new product development, these companies rely on R&D conducted at centralized facilities in the United States.

In sum, although Canada has accounted for an increasing share of North American vehicle and parts production over the past two decades, Canadian auto-sector expenditures on R&D as a percentage of sales remain extremely low compared with those of the United States and other countries.

Technology Strategy and Business Strategy

The lack of R&D in the Canadian parts sector adversely affects prospects for competitiveness. Globally, the structure of the auto-parts sector is greatly changing as is its relationship with vehicle assemblers. This change puts a premium on parts suppliers' technological and innovation capabilities. As well, the impact of foreign nameplate vehicles produced in North America, the part of the sector with the greatest growth in the North American market, will intensify the technological demands (including R&D) on Canadian firms.

The "technology strategy" of a company is described as either "adopt and adapt," if the company buys or transfers technology and perhaps makes some minor adaptations to fit its particular situation; "innovation," if the company uses its own or another's research, or takes technologies that are available, and produces an original or innovative product or process; or "breakthrough," if the company conducts its own research to produce a product or process at the forefront of technology. (See appendix for more details.)

The technology strategy of the Canadian auto-parts sector can be summed up as adopt and adapt. The sector imports machinery as close to state-of-the-art as commercially available or affordable, and then capitalizes on historically lower Canadian labour costs. The business strategy underpinning this approach is differentiation by low manufacturing costs, as illustrated in figures 2 and 3. Although this strategy has been highly successful, the rapid restructuring of the industry now calls it into question.

In general, very few Canadian parts firms — perhaps only about 2 per cent — have a technology strategy of innovation, using either proprietary technology or manufacturing processes as a basis for differentiation. Although examples are few, the most successful Canadian auto-parts firms *have* relied on innovation for their superior growth rates. For example, Woodbridge, a Canadian-owned manufacturer of moulded foam, seating, and instrument panels, used product and process innovation to increase its sales from $30 million in 1978 to $1 billion by the end of the 1980s. Magna International was technologically innovative and became a $2-billion company. Other examples of innovative Canadian companies are Court Industries and the ABC Group.

Implications of International Restructuring for the Global and Canadian Automotive-Parts Sector

Auto assemblers worldwide are in a very competitive contest for global markets. They are putting relentless pressure on parts suppliers to cut costs, enhance quality, and improve their product and process technologies.

The international auto sector is restructuring along the lines of the post-Japanese model. The competitive advantages this model gives to both assemblers and suppliers over the traditional structures make change inevitable. Western assemblers will be forced to rationalize their operations to compete with the Japanese. And this, in turn, will lead to fewer, larger, and more capable suppliers.

Figure 2. Technology strategies of Canadian firms in the automotive-parts sector

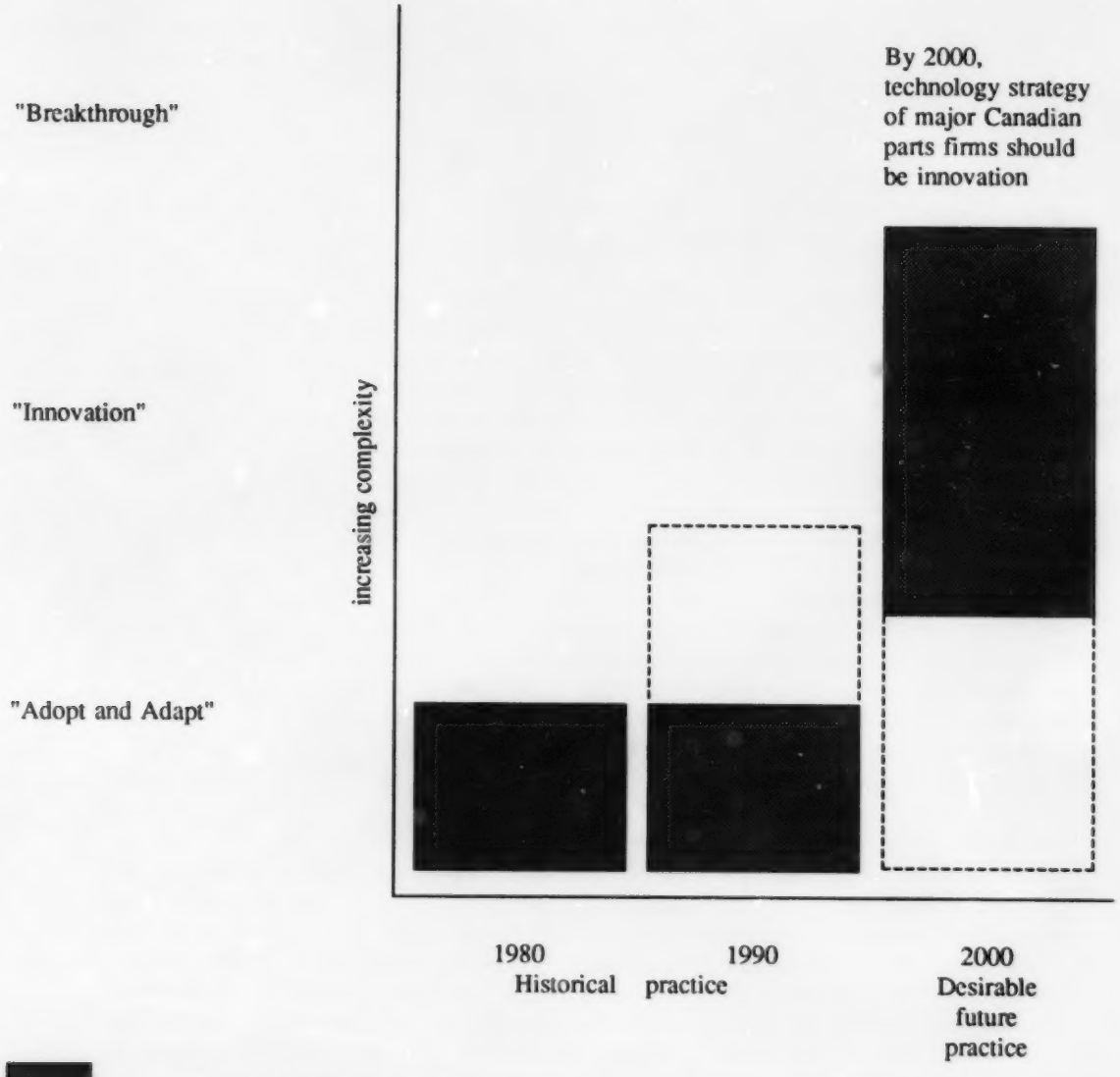
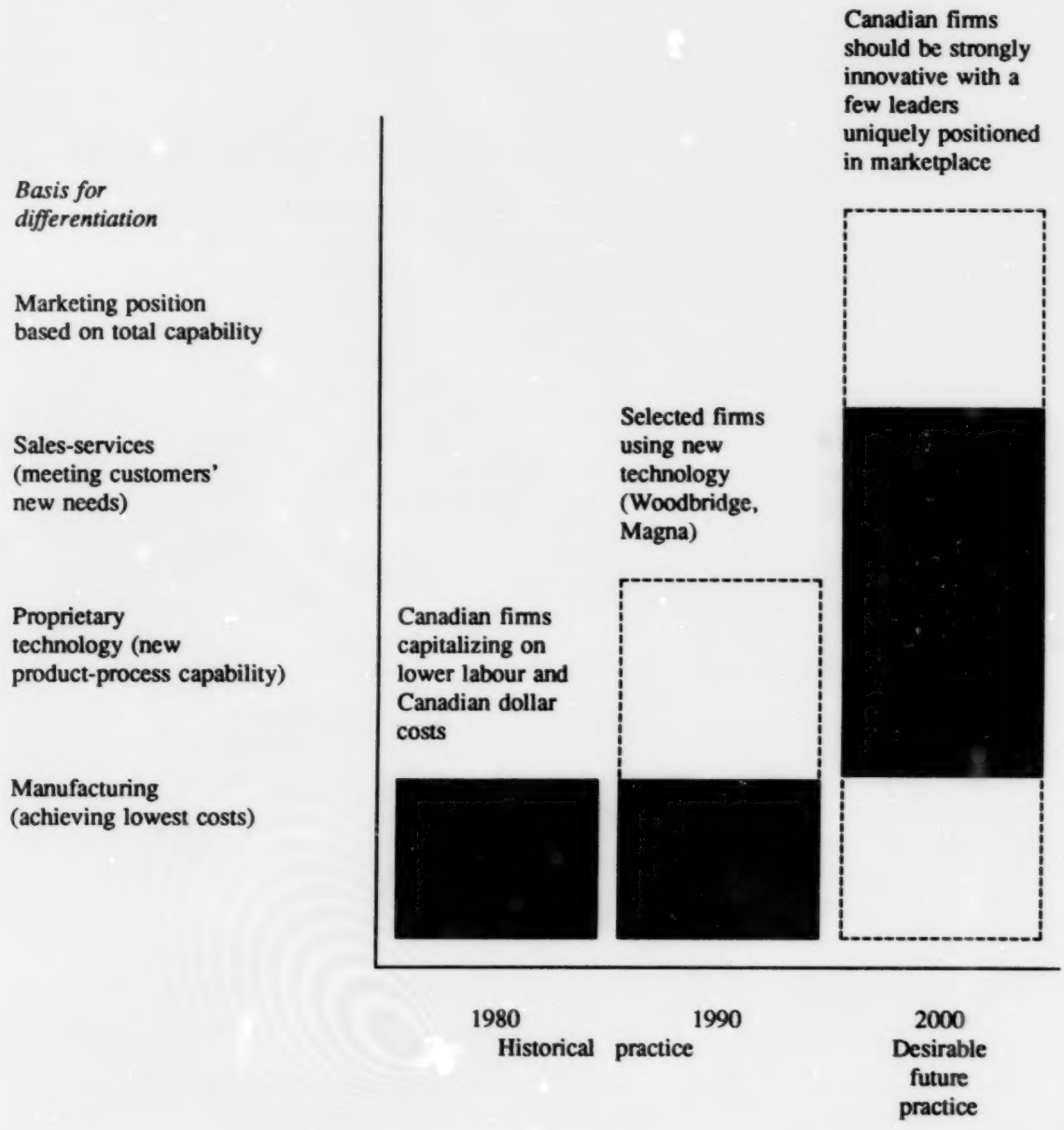

"Breakthrough"
"Innovation"
"Adopt and Adapt"
increasing complexity
By 2000, technology strategy of major Canadian parts firms should be innovation
1980 Historical practice
1990
2000 Desirable future practice
primary strategy for most firms
additional strategies that are important to selected other firms

Figure 3. Business strategies of Canadian firms in the automotive-parts sector


Canadian firms should be strongly innovative with a few leaders uniquely positioned in marketplace
Basis for differentiation
Marketing position based on total capability
Sales-services (meeting customers' new needs)
Proprietary technology (new product-process capability)
Manufacturing (achieving lowest costs)
Selected firms using new technology (Woodbridge, Magna)
Canadian firms capitalizing on lower labour and Canadian dollar costs
1980 Historical practice
1990
2000 Desirable future practice
primary strategy for most firms
additional strategies that are important to selected other firms

Increased specialization of vehicles, more designs, and shorter model lives mean that parts producers must develop products faster and at smaller volumes. New technologies that produce electronics, composite materials, and plastics, as well as advanced mechanical systems such as multi-valve engines, are being adopted by automakers seeking to differentiate their vehicles from those of other manufacturers.

Despite some resistance to change from the auto companies, the competitive problems facing the industry are too great for the situation to remain static. A partnership between OE manufacturers and Tier 1 suppliers will continue to emerge similar to the Japanese model. When overcapacity grows in the global automobile industry or demand falls, the real changes will begin. Because this restructuring is being imposed on the North American industry by overseas-based competition, Canadian firms not only have to reach world-class technological capability, but they also have to demonstrate that they can sustain it over the long term.

Japanese assemblers are not necessarily obliged to give purchasing contracts to Canadian parts firms, even if the firms have upgraded their technological capabilities. To support transplants, Japanese companies can import components from Japan, encourage further North American investments by Japanese parts suppliers, or do both.

Japanese companies could pursue competition at the R&D level. They could ask for proposals from North American and Japanese-based suppliers for an assembly, from design to product. This strategy would make breaking into the Japanese assembler's market a long-term prospect for many North American firms, and some might not survive the waiting period.

This prospect suggests a new role for marketing. Understanding customers' needs will be essential for auto-parts companies to survive. Parts suppliers will have to be on the doorstep, or even inside, the assembler's operations. They will have to communicate — and demonstrate — their capabilities. The marketing effort that will be required could be more costly than the R&D; it might involve as many engineers — over a longer period — as an R&D effort, to establish credibility with the assembler.

The upheaval in the sector will create opportunities for parts companies that demonstrate manufacturing-cost superiority, produce high-quality parts, interact as equals with automakers, and implement new technologies. The reward for those companies will be more predictable business because of long-term contracts and potentially better profitability because of higher value-added work.

Nevertheless, North American, and especially Canadian, auto-parts suppliers face tremendous challenges. At the same time that business prospects are shrinking because of imports and transplant vehicles, North American parts suppliers must take on greater responsibility for developing products.

To determine the "technical sophistication" of auto-parts suppliers, Booz Allen & Hamilton Inc. used an "engineering intensity index," defined as engineering expenditures as a percentage of sales. The higher the index, the more a company uses its own R&D to design new products. Booz Allen & Hamilton Inc. found that for both U.S. and Canadian companies, the engineering intensity ranged from 1 to 2 per cent, with that of Canadian firms on a slightly upward trend. They concluded that the companies sampled reflect a tier of the OE manufacturing business that is at Tier 2 or Tier 3.[21]

At present the auto-parts sector in Canada and the United States invests between 4 and 5 per cent annually in capital equipment.[22] If either economies of scale or FMS is attempted, investment would have to rise. If the Volvo example of a 20 per cent higher investment for FMS is accurate, then new investment would be about 6 per cent or higher. This has to come from current profits; if they are 6 per cent or less, new investment would not be as easy to justify.

Japanese automakers can transfer their low capital costs to their family suppliers simply by allowing them temporarily to charge more for a part until the investment is paid for. But the independent U.S. and Canadian parts industry must simultaneously deal with demands for lower prices from auto companies and raise capital from outside sources. If production costs increase, foreign-based

multinationals can pull out of Canada and go elsewhere. They could, for example, go to the southern United States with its weaker unions, or to emerging industrial areas such as Mexico, especially if the latter has free trade with major markets in North America.

It is legitimate to wonder where the money will come from in Canada to pay for the involvement of suppliers in R&D, for increased capital spending so that suppliers can accommodate increased business caused by fewer parts companies selling to the auto companies, for robots, for training, for communications, and for CAD/CAM equipment. It is unlikely that internally generated funds will be sufficient, and the cost of capital for many companies is too high to justify their required short-term returns on investment.

Growth Strategies for the Canadian Automotive-Parts Sector

Actions by the Automotive-Parts Sector

Canadian parts suppliers can employ several strategies to ensure their viability and growth in the new competitive environment.

Adopt a Tier Structure

It can be argued that it is not surprising that the tier structure has not yet fully emerged in North America. The North American assemblers may be unwilling to reduce their engineering staff and rely on suppliers. Some anecdotal evidence suggests that North American assemblers are deliberately not contracting out engineering work. However, if their market share continues to erode, then there will be a sharp break or discontinuity in procurement strategies by North American assemblers. With reduced revenues, they will not be able to maintain their current levels of physical plant and human resources. They will be *forced* to look to parts suppliers for technology.

Thus, Canadian parts suppliers that pursue an innovation strategy now for Tier 1 status will likely gain in the longer run; if Canadian firms cannot pursue an innovation strategy, then even Tier 2 and Tier 3 Canadian firms must have state-of-the-art process capability.

Instead of relying on the OE manufacturers for direction, suppliers will have to determine consumer requirements and proactively respond to those requirements. The challenge for Tier 1 suppliers will be how to invest R&D dollars to support the technology strategy and achieve maximum value to the final customer. (This is not necessarily the same thing as reaching a certain level of R&D spending, say, as a percentage of sales.)

Companies that adopt this strategy will have proprietary technology or total system-integration capability. They will, in turn, have to manage their own suppliers.

Parts firms that do not offer engineered assemblies will be Tier 2 and Tier 3 candidates. Although the role of the secondary or tertiary supplier is often perceived as inferior to that of the primary supplier, it can be both lucrative and rewarding for properly organized companies. It is also a role that requires major technological capability: robotics, flexible manufacturing systems, statistical process control, and just-in-time production scheduling. A company such as 3M is a Tier 2 company because of its product, not because of size, capabilities, or resources.

Secondary and tertiary suppliers will concentrate more on process technology. This is a more realizable goal than the R&D and design capability implied by a Tier 1 firm's production of assemblies.

But secondary and tertiary suppliers will have to increase their understanding of the application and function of the assemblies in which their parts are used. They may also have to form business relationships outside the auto sector, to develop economies of scale and to use equipment more efficiently.

Moreover, secondary and tertiary suppliers will have to develop entirely new business relationships even within the auto sector. The key to their success will be linkages to Tier 1 suppliers. If Canada does not develop Tier 1 capability, then Canadian Tier 2 and Tier 3 firms will have to establish linkages with U.S.-based (and conceivably Japanese-based) Tier 1 suppliers. In general, Canadian parts firms are not linked to U.S.-located plants; they supply parts directly to assemblers' plants in Canada. Supplying U.S.-located plants will require them to develop new marketing initiatives, supported by new production methods, as called for by their new relationships.

From a national perspective, the issue facing the federal and appropriate provincial governments is whether Tier 2 or Tier 3 firms might prefer to move to the United States. If their critical relationships are shifting toward U.S.-based Tier 1 companies, the firms might move closer to their new customers. For example, a major Canadian parts firm — Tridon Ltd. — has announced it is moving to the United States.

A major benchmark in establishing a tiering system, from a national perspective, will likely be the emergence of Canadian-based Tier 1 suppliers. These firms will be the new focal point in the auto-parts sector.

Such a development could represent a great opportunity for Canada. Canada's automotive R&D up to now has been negligible. If R&D is decentralized, at least in part, to Tier 1 parts suppliers, there would be outstanding new opportunities for Canadian firms to contribute at the R&D level.

Integrate R&D with Advanced Manufacturing Technologies

As demands of assemblers on suppliers increase, suppliers realize that they must generate sufficient revenues through sales to support a substantial amount of sustained technological and marketing capability. Canadian suppliers realize that they will have to be bigger to satisfy these demands, yet they must never lose sight of the necessity to respond quickly to changes, the hallmark of small firms.

Suppliers usually quote R&D spending as a percentage of sales. For an individual company, R&D costs may be relative, but compared with competitors, they are absolute. To remain competitive in the auto-parts sector, R&D investment relative to sales (typically 1 to 5 per cent for major North American suppliers) may not be as important as the absolute value of the R&D investment.[23] Lamming suggests, as an example, the case of a firm realizing $250 million worth of sales. This firm would need to devote 4 to 5 per cent of its sales to R&D. This represents a reasonable "threshold floor" benchmark of R&D expenditures for a Tier 1 supplier. Larger companies investing 5 per cent of sales in R&D have an obvious advantage over smaller companies that would have to invest a considerably higher proportion of sales to achieve the same absolute level of R&D.

Another advantage of large auto-parts companies is economies of scale.[24] Suppliers will discover they have to amortize the costs of development and prototyping in the production costs per final unit. This means that major assemblies that incorporate complex and expensive electronics technology, for example antilock breaking systems, necessarily have a break-even production level of about two million units per year to justify R&D costs. In turn this suggests specialty suppliers, because at this level of output the supplier must have more than one customer. In sum, the specialty supplier produces components at a scale that is economically viable and also builds up technical expertise in developing and producing the part.

High R&D costs raise the question of what would happen with R&D projects initiated by the assembler and undertaken either by the supplier alone or jointly with the assembler. If a product from the research has a large break-even production volume, the supplier would obviously need to sell to more than one assembler. But the supplier could be restricted to supplying only one assembler. Research projects initiated by the supplier would not be subject to the same restrictions. For some types of components, therefore, there is a strong argument for encouraging greater R&D at the supplier level: a supplier could access more than one assembler with new products.

Even more important than scale of R&D is its quality. In particular, it must recognize *systems integration*. A parts supplier must link its creative design with the needs of manufacturers. The supplier must also coordinate just-in-time delivery processes, inventory control systems, and lower-tier suppliers to produce a complete assembly, not just a component. This means linking — in the research lab as well as on the shop floor — tool-and-die makers, materials professionals such as metallurgists and chemical engineers, CAD technicians and designers, and production engineers. It is this

interdisciplinary R&D that the Japanese have recognized first and exploited so adroitly. North American industry has a way to go to reach this level of organization.

New CAM technologies (flexible manufacturing systems) that reduce retooling and setup times, and enable shorter, economical production runs are already in place in some manufacturing sectors; therefore, large runs of a single item to achieve economy of scale may not be necessary in the future. Nevertheless, from the firm's point of view, total company sales have to be large enough to support any given R&D effort. Hence, in the future, the "threshold" entry level for an auto-parts firm (at least, for a Tier 1 firm) will likely be set by R&D-engineering requirements, rather than production facilities.

Any strategy for innovation by the Canadian auto-parts sector must approach new technology at three levels:

1. Systems R&D: For an auto-parts company to reach Tier 1 status it must integrate a variety of technologies into new processes or marketable new products. The emphasis for R&D will therefore be on development, not research, and will concentrate on final assemblies (systems) offering better value to the ultimate consumer — the car buyer.

2. Technology diffusion: Systems integration requires an understanding of related and supporting technologies and the ability to apply them to the organization's production processes.

3. Skills upgrading: The rapid pace of technical change requires that technical staff — engineers and technologists-technicians — constantly update their skills so that they understand new technologies and can apply them to the auto-parts sector.

Make Acquisitions and Alliances

Acquisitions are one approach by which suppliers can rapidly achieve the size needed to exploit full service and economy of scale in production and R&D. Another approach is to form alliances with other companies to capitalize on each other's strengths.

A worldwide presence is critical for firms in the auto sector over the next few years. Most Japanese automobile manufacturers will eventually have assembly plants in North America, Europe, and elsewhere. General Motors and Ford already have international assembly and Chrysler is re-entering the international arena with joint ventures in Europe (Renault-Jeep) and China (AMC-Beijing Jeep). In addition the "families" of all assemblers are extensive and growing.

Any tiering of the auto-parts sector in Canada will have to capitalize on Canadian financial and intellectual strengths. Canadian materials companies — steel, aluminum, and chemical — are potential strengths as well as a link to the auto-parts sector. Some work in auto-parts applications is already under way by companies such as Alcan, but in general the level of effort by Canadian materials companies is as yet very small — perhaps a legacy of previous cost-cutting purchasing strategies by the major North American vehicle manufacturers.

Suppliers will be expected to support car production throughout the world in the next decade. Some major suppliers have worldwide operations already. For Canadian suppliers that wish to compete, the formation of offshore alliances will be particularly important.

Improve Management Techniques

Adding R&D to a firm's capabilities is no substitute for management skill and judgement. Perhaps more important than the amount spent on R&D is how R&D is organized and managed. Graves, in a comparative study of U.S., European, and Japanese automotive R&D, noted that although the United States and Europe spent in total considerably more on R&D and had considerably more R&D

personnel than did Japan (1984 figures), the amount spent or number employed had little bearing on the relative performance of the United States in the marketplace.[25] The same paradox was found at the company level. In 1985, GM's spending on R&D was greater than the total R&D spending of the four major Japanese companies.

Japanese investment in R&D has been increasing since the 1970s, and their current level of investment may now be closer to that of the United States if investment by Japanese auto-parts companies is included in the figures. But the amount does not explain the phenomenal rise of the Japanese automotive industry. The difference in returns on investment in R&D are attributed to qualitative differences between Japanese and North American and European R&D systems.

The fundamental difference between the organization of R&D in the United States and Japan is that "Japanese firms put increasing emphasis on employing the most highly trained engineers and workers *throughout* the system."[26] In contrast, "U.S. companies have tended to 'polarise' operations by employing an increasingly skilled R and D task force on the one hand, and an increasingly de-skilled workforce on the shop floor on the other."[27] The Japanese organization stems from the training engineers receive when they join a company. In their first year they spend time on the shop floor and in sales and marketing, as well as in different R&D departments. During the next few years they work in various divisions of the company so that by the time they manage research projects they understand all aspects of the company. R&D personnel in U.S. companies receive very narrow training and seldom have contact with other areas of the company. The technical expertise of project managers is emphasized in the United States, whereas ability to manage people is emphasized in Japan.

The Japanese "dynamic system of R and D," as Graves calls it, means that R&D and technical expertise and knowhow are embodied in the whole company, from top management to the shop floor.[28] This results in reduced lead times for product development, "people embodied technology," incremental and rapid technical change, and engineers knowledgeable about product and process development, production, and marketing. The Japanese R&D system "cannot be isolated from the production and marketing system, and . . . cannot be understood without considering the substantial time involved in the professional development of R and D engineers."[29]

The more innovative Canadian parts suppliers work on the Japanese principles. For example, a highlight of the Woodbridge Group's technical effort is not just product R&D, but also "proof of new product process capability." A new product is fully integrated into the firm's production in all respects, including production speed and quality, with no negative impacts on plant flexibility.

Enhance Technology Strategy

All business options in the restructured auto sector involve developing a new technology strategy as well as a commitment by management to pursue that strategy for long-term viability. The major decision will be at what level in the tier structure the company wants to compete and whether it has, or can get, the resources to pursue the strategy. For would-be Tier 1 suppliers, the technology strategy must be based on "innovation," or even "breakthrough"; "adopt and adapt" will not be sufficient. For would-be Tier 2 and Tier 3 suppliers, an adopt and adapt strategy will remain a reasonable option — provided that such firms always know what represents state-of-the-art process technology and management techniques. For many Canadian firms, this will still involve acquiring greater engineering, marketing, and management skills than they have at present.

Government Support

Because the Canadian auto sector is so closely tied to the fortunes of the North American sector, the success of the Japanese poses a threat to Canada's traditional auto-parts sector. Japanese automakers

have invested locally, thereby limiting the effectiveness of quotas and tariffs. Local-content legislation, including R&D content, is an option. This legislation may restrict the Japanese because it raises the "threshold" of total investment that is required. However, in the long run, it could equally encourage even more rapid development of a Japanese supplier base in North America which, by present technological comparisons, would tend to put more Canadian firms out of business. Much more proactive technological development by Canadian firms is required, with governments helping to encourage a general innovation climate.

There are, however, actions that governments can take to support and strengthen the domestic parts industry. In interviews conducted for the Science Council of Canada, executives in some of Canada's leading auto-parts firms identified two priority areas in which they felt governments should take action — Revenue Canada should interpret R&D more flexibly and financing for R&D should be more readily available.[30] Other areas for government support include direct support for cooperative R&D and sector-specific skills upgrading.

Allow a More Flexible Interpretation of R&D

Canadian auto-parts executives generally feel that despite improvements, Revenue Canada's interpretation of R&D may still not do justice to the emerging realities of the auto sector. Revenue Canada's interpretation is important because it is used in calculating R&D tax benefits and in determining whether companies qualify for government R&D support programs.

In a 1989 survey for the Science Council of Canada, auto-parts executives felt that clarifying the interpretation of R&D to make it more flexible and realistic would better enable the parts sector to obtain tax support for its R&D. As a result of Revenue Canada's interpretation, government tax incentives and programs supporting private sector R&D were seen as too focused on the research end of the R&D spectrum. The interpretation of experimental development as opposed to routine engineering required clarification. In a sense, the R&D tax credits were more clearly focused on "breakthrough" technology strategies rather than on "innovation" or "adopt and adapt." Industry, Science and Technology Canada has already taken a lead role in establishing consultative discussions with Revenue Canada on this matter, and, among other things, a helpful formal information circular setting out clearer policy has now been released. This is a step in the right direction.

Respondents to the Science Council's survey suggested that Revenue Canada's separation of ongoing product improvement and process R&D from new-product R&D is unrealistic in the auto sector, especially for parts suppliers. Most of the R&D undertaken by parts companies in Canada is customer-driven or process-related. Parts firms are required by assemblers not only to prove the concept of a new product, but also to prove the process for making it. Over time, if there is more R&D in product development and "proof of process," as there should be in Canada, the issue of what constitutes R&D will return. The issue must be decided on the basis of what industry needs to meet its goals — not what is an acceptable trade-off today.

Make Financing for R&D More Readily Available

The inability to obtain financing or financial support is another major impediment to expanded R&D in Canada. A recent report suggests that, in general, capital financing is not a major problem in the auto-parts sector because of offshore financing (for example, from the United States).[31] However, all the auto-parts executives interviewed in the Science Council study cited difficulties in obtaining financing for R&D. These difficulties are in the high capital expenditures to purchase the specialized equipment required for R&D and in expenditures to maintain sufficient personnel.

Obtaining financing for R&D from conventional sources, according to those interviewed, is extremely difficult, if not impossible. The conservative outlook or lack of technical understanding of financial institutions, such as banks, often results in little support. Related to this inability to obtain

financing is the bottom-line sensitivity of research investment. If financing is not available, then any R&D expenditures become an immediate debit and thus directly affect a corporation's bottom line. Accordingly, it is imperative that Canadian firms maintain a positive cash flow, from which to finance R&D.

This is particularly important because of the pressure for public companies to maintain acceptable short-term returns on their stockholders' investments. But many people have stated that research investment requires a long-term focus. With the exception of Magna International, it may be no accident that Canadian auto-parts firms that conduct R&D, such as Woodbridge Foam, are private companies whose owners are well aware of the need to preserve their long-term investments. Their business strategies therefore may involve a more central role for technology than the business strategies of most public companies. Short-term profits may be reduced for market share gains. This raises the question of whether government policy to encourage private ownership could be put in place — conditional on growth technology strategies in the firm.

Support Technology Diffusion

Because of limited financing for R&D, it is imperative Canadian industry does not waste it by "re-inventing the wheel." A mechanism is needed to make available to Canadian automotive firms technological information that is in the public domain.

One mechanism might be a technology resource centre that could act as a "data clearing house" for the Canadian sector. The emphasis of this centre must be on marketable applications of technology rather than on basic scientific knowledge. Such a centre, perhaps supported with public funds on a fixed-term experimental basis, and perhaps limited to two or three subsectors of the auto-parts sector, could conceivably initiate a *development* network. This network could help Canadian firms upgrade their technological depth in the right direction. A key factor would be to staff the centre with people both knowledgeable about the changes in technology that might affect the industry and imaginative enough to associate those changes with opportunities for Canadian firms.

Upgrade Sector-Specific Skills

Because of the rapid pace of technological change in the auto-parts sector, and the need to respond to the new industry environment, programs for skills upgrading are a high priority.

There may, however, be subtle but important differences in the motivations of firms to obtain better-qualified workers in Canada. For example, offshore firms entering Canada will already have their own product and process technology and may need more general skills to provide an adequate base for their specific on-the-job training. Experience will be less of a concern.

On the other hand, Canadian-based firms may be looking for people with experience with the new technologies, and perhaps with the ability to provide input on technological upgrading plans and to train people to use the technology.

Skills upgrading programs will have to consider the different needs of the companies and may have to give priority to selected areas of technology in the auto-parts sector. Co-op programs that combine theory with work experience would be desirable.

If Canadian firms concentrate on a limited number of technological areas, then skills upgrading should be tailored to domestic needs. Accordingly, although important, skills upgrading needs to respond to industry's needs and, subject to actions by firms, may not necessarily be a top priority for government action in this sector.

Develop a Mutual Action Plan

A concerted effort should be made by all interest groups, including auto-parts firms, auto assemblers, governments, research facilities, and trade associations, to develop a specific action plan. This plan would specify technology goals, memorandums of understanding between all the players, and accountabilities.

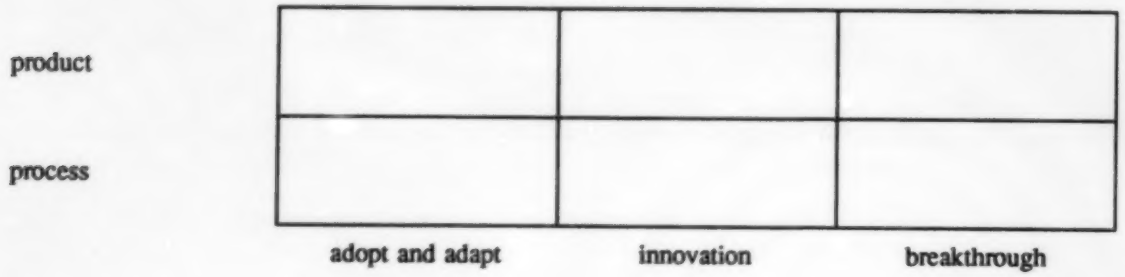
Conclusion

At present, because of the profitability and cash-flow situation the firms face, there is only limited potential for increased R&D in the Canadian auto-parts sector. Most Canadian auto-parts suppliers have neither the resources to undertake R&D nor the capacity to become single-source suppliers. Further restructuring of the sector will likely be required before R&D thresholds can be reached. The alternative to Canadian-directed restructuring is liquidation of Canadian investments. Many firms would go out of business, and economic growth and activity, especially in the manufacturing provinces of Ontario and Quebec, would be damaged. It would be sad if liquidation occurred, because the new tiering structure for auto-parts manufacturing gives Canadian firms an outstanding new opportunity to develop R&D in particular and technological capability in general. They have not realistically had this opportunity in the past, but they must muster the intellectual, financial, and managerial skills required.

New competitive circumstances require cooperation to prepare an action plan for governments and industry. This plan would strengthen efforts to enhance technology strategies and R&D in the auto-parts sector in Canada.

Appendix: Framework for Technology Strategies

As part of the methodology for analysing each sector, the Science Council of Canada sought whenever possible to assess company technology strategies according to the following framework:



Strategy Classes

Adopt and Adapt: Acquire a technology and adapt it to serve as a competitive platform.

Innovation: Incrementally improve on winning technology to get greater market share or maintain competitive edge.

Breakthrough: Seek to create a discontinuity in the marketplace, thereby leaping ahead of the competition.

The company case studies generally looked for at least seven key dynamics influencing a company's technology strategy:

- three internal dynamics:
  - competitive position,
  - capacity for innovation, and
  - strategy and vision; and
- four external dynamics:
  - customer demands,
  - competitive rivalry,
  - supply condition, and
  - available technology.

The methodology also incorporated essentially a three-step process for each sector. In the first step one or more contractors analysed the main elements in the competitive and R&D performance of the Canadian sector and its leading foreign competitors. The second step included evaluation of the contract report(s), discussion with contractors and other experts, additional in-house research, and preparation of a draft Council report. In the third step, external reviewers commented on one or more drafts of the Council report, which were then revised and refined as required, drawing on the advice of the liaison person for that sector on the Steering Committee (see Acknowledgements). For some sectors, the third step also involved several external reviewers in a small workshop, one part of which

helped define some elements of a potential action plan for the sector. The report was then submitted for final approval to the Executive Committee of the Science Council, before being forwarded to Industry, Science and Technology Canada.

Notes

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2. Paul Ingrassia, "Losing Control: Auto Industry in U.S. is Sliding Relentlessly into Japanese Hands," *Wall Street Journal*, 16 February 1990, 1.

3. A. Graves, "Comparative Trends in Automotive Research and Development," briefing paper delivered at First Policy Forum, International Motor Vehicle Program, Massachusetts Institute of Technology, 5 May 1987.

4. Maryann Keller, "Automotive Parts," contract report prepared for Science Council of Canada, 1989 (unpublished), 6.

5. Richard Lamming, "The International Automotive Components Industry: The Next 'Best Practice' for Suppliers," IMVP International Policy Forum, Massachusetts Institute of Technology, May 1989, 2.

6. Ibid., 3.

7. Ibid., 9.

8. Although the Auto Pact allowed free trade in assembled vehicles and original equipment parts for qualified manufacturers, it did not cover aftermarket parts. This situation has been addressed by the Canada-United States Free Trade Agreement, which will remove all tariffs on aftermarket parts by 1994.

9. DesRosiers Automotive Research Inc., "Product Research and Development in the Canadian Automotive Parts Industry," contract report prepared for Science Council of Canada, 1989 (unpublished), 5.

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11. Ibid., 7.

12. Ibid., 6.

13. Booz Allen & Hamilton Inc., op. cit., III-2.

14. Ibid., II-20–II-21.

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20. Industry, Science and Technology Canada, Automotive Directorate, *Product and Process Development in the Canadian Automotive Sector* (Ottawa, January 1990), 8.

21. Booz Allen & Hamilton Inc., op. cit., III-5.

22. Ibid., III-4.

23. Richard Lamming, op. cit., 12.

24. Ibid., 12.

25. A. Graves, op. cit., 16.

26. Ibid., 17. It should be noted that although Graves specifically mentions engineers, the opportunities to enhance productivity in the automotive sector through training and skills upgrading extend far beyond the engineering profession.

27. Ibid.

28. Ibid., 16-17.

29. Ibid., 1.

30. DesRosiers, op. cit., 15. The Science Council of Canada retained DesRosiers Automotive Research Inc. of Toronto to interview executives of 14 Canadian and foreign-owned automotive-parts operations. These companies are all major players in the industry; most are part of corporations having annual sales in excess of $250 million.

31. Booz Allen & Hamilton Inc., op. cit., 6.